Inchcape Testing Services
Dash, Straus & Goodhue

Dash, Straus & Goodhue, Inc.
593 Massachusetts Avenue
Boxborough, MA 01719
Telephone (508) 263-2662
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April 19, 1994

Mr. Ronald Vicari
Director - Network Systems
Geotek Communications, Inc.
20 Craig Road
Montvale, New Jersey 07645

Dear Mr. Vicari:

On April 18, 1994, we measured the interference potential of signals present within the notch as defined in §90.209(h) for a 4 watt transmitter. §90.209(h) describes the bandwidth mask from the center frequency of the assigned channel to 15 kHz above and below the center frequency. Emissions beyond 15 kHz from the assigned channel are to be reduced from the carrier level by 56 dB per §90.209(h)(4).

The interference potential was determined by varying the level of signal (called the interferer) within the notch from the legal limit to a proposed level of -56 dBc. These measurements were made while energy levels in compliance with the bandwidth mask are present along the curve defined in §90.209.

The following procedure was used to demonstrate the interference potential. Please feel free to contact me if you have any questions or comments. I can be reached at (508) 263-2662 or by FAX at (508) 263-7086.

Sincerely,

Joseph B. Woodworth

Joseph B. Woodworth
EMI Section Manager

jbw

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Introduction

The guidelines of §90.209(h) require that emissions within the range 12.05 kHz to 15.0 kHz from the assigned channel be decreased according to the equation $157 \cdot LOG_{10} (f_d/5.3)$ dB, which results in a level of -70.9 dBc at a distance 15 kHz from the assigned frequency. However, emissions from a 4 Watt transmitter are allowed to be present at a level of -56 dBc if outside of the 15 kHz window. The difference is 14.9 dB.

The measurements performed in this investigation were intended to determine whether energy within the band (or notch), from 12.05 to 15 kHz can cause harmful interference to existing radio services when the transmitter on the adjacent channel transmits full power (assumed to be 4 Watts) and is completely within the bandwidth mask of §90.209(h).

The methodology for this determination is outlined below, and simply consisted of the generation of a simulation signal representing a fully-compliant system and increasing the energy at the point of the notch to the recommended level of -56 dBc, below the level of the 4 Watt transmitter. The receiver's capability of receiving a signal when energy is present is monitored while the energy is present at compliant levels, and the recommended levels.

The possibility of interference is present when signals within the notch are received by the base station instead of the intentional signal. Since the structure of the SMR frequencies are paired, mobile radios will not receive at frequencies adjacent to mobile transmit frequencies. For measurements, three mobile radios were obtained and used to simulate the receiver circuitry in the base station. The mobile radios were selected to represent the base station as the technology is expected to be equal to, or of lesser quality than the receiver technology incorporated in an actual base station.

Procedure

1. The following assumptions were made for these measurements:
   a. The total power transmitted from the product is 4 Watts. This power is used to determine the appropriate bandwidth mask, as well as to determine the equivalent radiated power and field strength at each particular frequency within the mask.
   b. The mobile transceiver is never expected to be closer than 100 meters to the receiving base station (base station for adjacent channel).
   c. The mobile transceiver transmits full power, automatically, which is worst case.
   d. The receive antenna for the base station and mobile antenna are on the same horizontal plane.
   e. The antenna gain is assumed to be 1.64.

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2. Two channels are of concern for this investigation. These two channels are identified in this report as the *Occupied Channel* and the *Adjacent Channel*. All measurements were made at the Adjacent channel which was one channel lower in frequency than the Occupied Channel. The Occupied Channel simulates the presence of the 4 Watt radio.

Before application of the potentially interfering signal within the notch, energy was placed along the bandwidth mask to simulate the presence of a fully-compliant emission at the Occupied Channel. The levels of these signals were determined by calculation of the field strengths at a distance of 100 meters using the equation as follows:

$$E = 1.64 \left(^{5.5}/_{r}\right) * \sqrt{P_t}$$ where:

r = 100 meter distance
P_t = Power at frequency

Signals compliant with the mask were placed at two points along the curve to simulate the presence of energy in the Occupied Channel. The first point, referred to as f_{I2} was placed at the point in the curve which was attenuated from the peak level of the Occupied Channel by 56 dB. This point was 0.45 kHz from the Adjacent Channel and was 12.05 kHz from the Occupied Channel. The second point was present 2.5 kHz higher in frequency than the Adjacent Channel and is identified as F_{I3}.

The frequency where the potential for interference is present is identified as F_{I1} and is at the point 15 kHz removed from the Occupied Channel, or 2.5 kHz lower in frequency than the Adjacent Channel. The Occupied Channel is identified as F_{OC} and the Adjacent Channel is identified as F_{AC} in the following tables.

The following table summarizes the levels which are allowed according to the bandwidth mask of §90.209(h):

Identifier	Location	Limit (dBc)	Limit (dBμV/m @ 100m)
F_{I1}	F_{OC} - 15 kHz	-70 or -56	34 or 49
F_{I2}	F_{OC} - 12.5 kHz	-58.5	46
F_{I3}	F_{OC} - 10 kHz	-43.3	63

Please note that the limit in dBc is the amount from the carrier level (without modulation) that the signal at that particular point (when signal is modulated) must be attenuated. The limit in dBμV/m @ 100 meters has been calculated after determining the power at that specific frequency.

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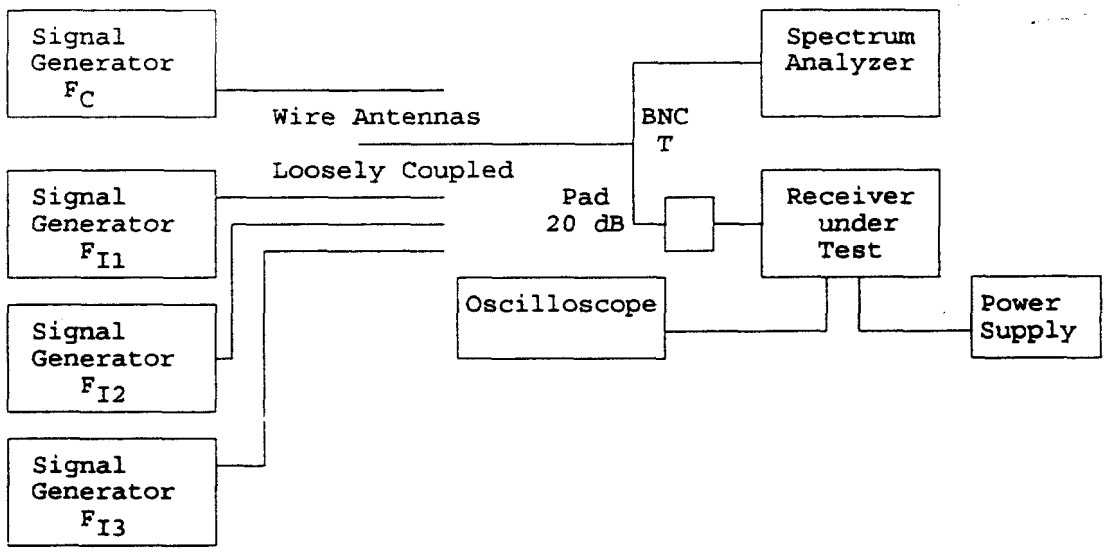
3. The following configuration shows how the equipment was configured for measurements:



The equipment used for measurements was as follows:

Spectrum Analyzer	Hewlett Packard	8593A
Signal Generator	Hewlett Packard	8656A
Signal Generator	Hewlett Packard	8656B
Signal Generator	Fluke	6071A
Signal Generator	Hewlett Packard	3200
Oscilloscope	Tektronix	465

4. The equipment was configured as shown above. As seen in the drawing, the signal generator outputs were loosely coupled using short monopole antennas. The levels fed into the receiver were monitored using the spectrum analyzer. A 20 dB attenuator was added to the receiver under test to increase the signal to noise ratio of the spectrum analyzer as the receiver sensitivity in some cases approached the noise floor of the instrumentation.

5. Three commercially available receivers, a Uniden America SMS-925TS (S/N: 35000534), a Motorola D37MWA5687 (S/N: 436ATY0432), and a Kenwood TK-931 (S/N: 41100290) were investigated. The squelch features and external gain controls were minimized for all measurements in order to maximize the potential for interference to the receiver.

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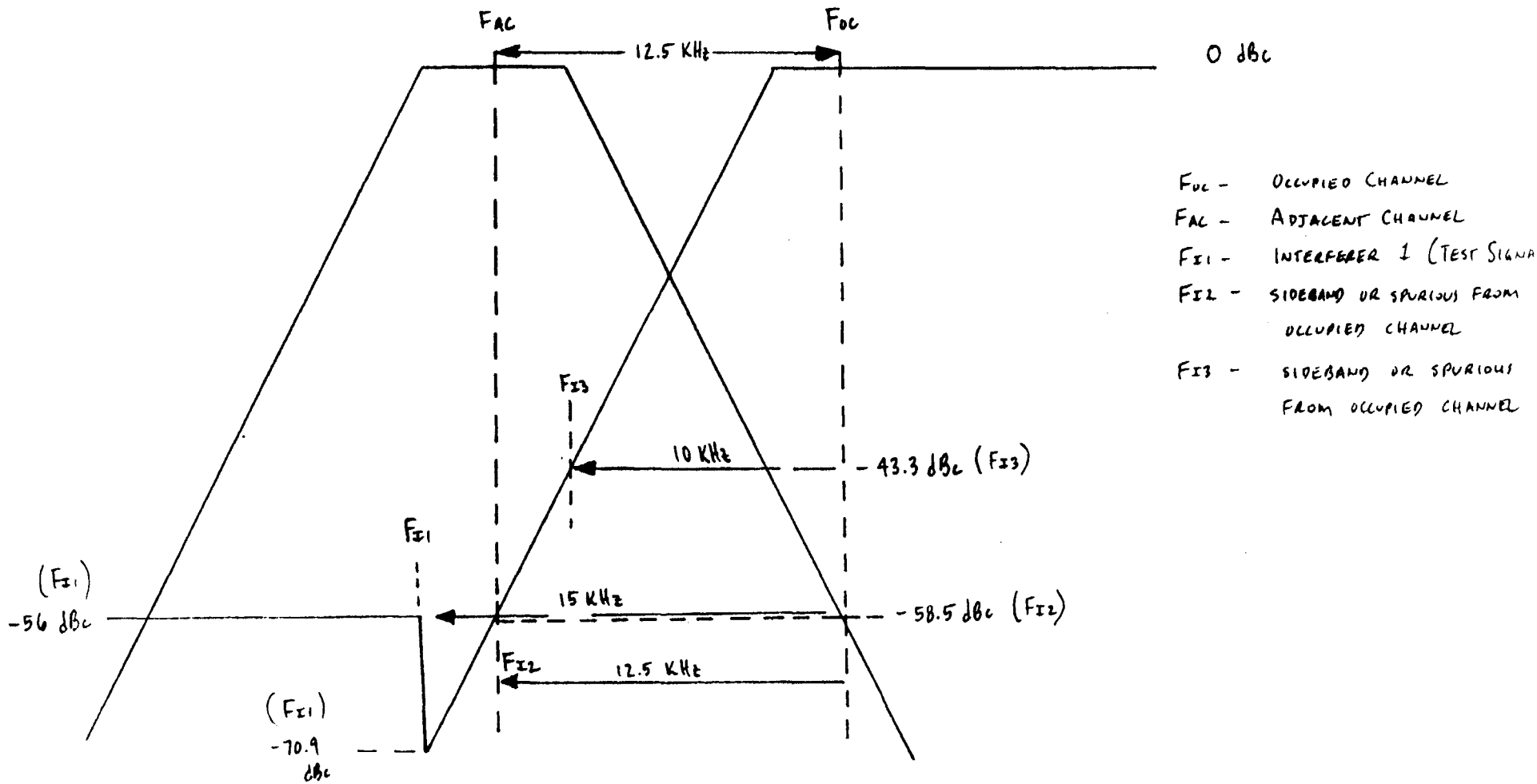
6. With signals F_{I2} and F_{I3} present at the levels shown, a signal was applied at F_{I1} which was set at the lower limit of -70.9 dBc [from §90.209(h)]. In this condition, a modulated signal was applied at F_{AC} and the level was increased until the modulated signal was detected at the receiver. Please note that the audio frequency modulation output was monitored using the oscilloscope to determine the threshold of sensitivity.

   Once the modulation appears on the oscilloscope, the level of the signal on the spectrum analyzer is recorded. The level of F_{I1} is then increased to the proposed higher level -56 dBc which, according to §90.209(h)(4) can be applied to emissions removed from the assigned frequency by greater than 15 kHz. The modulation shown on the spectrum analyzer is viewed, and the sensitivity is again measured.

   In all cases, variation of this signal from legal limit to the proposed limit of -56 dBc made no significant changes to the equipment sensitivity. Please note that equipment sensitivity under these conditions may not be the actual equipment sensitivity as defined in the manufacturer's specifications. Equipment sensitivity is defined here as the threshold where the modulation from F_{OC} is present on the oscilloscope.

   The tables shown on the following pages detail the results of the tests. Please note that the presence of F_{I1} will cause the level of F_{AC} to increase if the F_{I1} causes interference.


FAC
FOC
12.5 KHz
0 dBc
FOC - OCCUPIED CHANNEL
FAC - ADJACENT CHANNEL
FI1 - INTERFERER 1 (TEST SIGNAL
FI2 - SIDEBAND OR SPURIOUS FROM OCCUPIED CHANNEL
FI3 - SIDEBAND OR SPURIOUS FROM OCCUPIED CHANNEL
FI3
10 KHz
-43.3 dBc (FI3)
FI1
(FI1)
-56 dBc
15 KHz
-58.5 dBc (FI2)
FI2
12.5 KHz
(FI1)
-70.9 dBc

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Motorola M/N: D37MWA5GB7AK FCC ID: ABZ89FT5726		
Identifier	**Frequency (MHz)**	**Level (dBm)**
F_{I1}	935.010	-73
F_{I2}	935.013	-61
F_{I3}	935.015	-44
F_{OC}	935.025	n/a
F_{AC}	935.0125	-20
Please note that the level of F_{OC} as reported above is the sensitivity as defined in Part 6.		

Motorola M/N: D37MWA5GB7AK FCC ID: ABZ89FT5726		
Identifier	**Frequency (MHz)**	**Level (dBm)**
F_{I1}	935.010	-58
F_{I2}	935.013	-61
F_{I3}	935.015	-44
F_{OC}	935.025	n/a
F_{AC}	935.0125	-20
Please note that the level of F_{OC} as reported above is the sensitivity as defined in Part 6.		

Please note that when the signal at F_{I1} was swept from 935.010 into 935.0125 MHz, no degradation in the received modulation was observed. The measurement was repeated with F_{I1} set at 1.5 kHz from F_{AC} and a level of F_{AC} was determined to be -19.9 dBm.

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Kenwood M/N: TK-931 FCC ID: ALHTK-931-1		
Identifier	**Frequency (MHz)**	**Level (dBm)**
F_{I1}	935.010	-73
F_{I2}	935.013	-61
F_{I3}	935.015	-44
F_{OC}	935.025	n/a
F_{AC}	935.0125	-20.8
Please note that the level of F_{OC} as reported above is the sensitivity as defined in Part 6.		

Kenwood M/N: TK-931 FCC ID: ALHTK-931-1		
Identifier	**Frequency (MHz)**	**Level (dBm)**
F_{I1}	935.010	-58
F_{I2}	935.013	-61
F_{I3}	935.015	-44
F_{OC}	935.025	n/a
F_{AC}	935.0125	-20.0
Please note that the level of F_{OC} as reported above is the sensitivity as defined in Part 6.		

Please note that when the signal at F_{I1} was swept from 935.010 into 935.0125 MHz, no degradation in the received modulation was observed. The measurement was repeated with F_{I1} set at 1.5 kHz from F_{AC} and a level of F_{AC} was determined to be -20.8 dBm.

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Uniden M/N: SMS 925TS FCC ID: AMWUL038		
Identifier	**Frequency (MHz)**	**Level (dBm)**
F_{I1}	938.010	-73
F_{I2}	938.013	-61
F_{I3}	938.015	-44
F_{OC}	938.025	n/a
F_{AC}	938.0125	-20.8
Please note that the level of F_{OC} as reported above is the sensitivity as defined in Part 6.		

Kenwood M/N: TK-931 FCC ID: ALHTK-931-1		
Identifier	**Frequency (MHz)**	**Level (dBm)**
F_{I1}	938.010	-58
F_{I2}	938.013	-61
F_{I3}	938.015	-44
F_{OC}	938.025	n/a
F_{AC}	938.0125	-20.9
Please note that the level of F_{OC} as reported above is the sensitivity as defined in Part 6.		

Please note that when the signal at F_{I1} was swept from 938.010 into 938.0125 MHz, no degradation in the received modulation was observed. The measurement was repeated with F_{I1} set at 1.5 kHz from F_{AC} and a level of F_{AC} was determined to be -20.5 dBm.

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Summary

Measurements with three receivers demonstrate that the energy at the frequencies from 12.05 kHz to 15 kHz from the channel can be increased from -70.9 dBc as required by §90.209(h) to -56 dBc without causing significant degradation of the receiver on the adjacent channel sensitivity.

Please feel free to contact me if you have any questions or comments. I can be reached at (508) 263-2662 or by FAX at (508) 263-7086. Thank you.

Sincerely,

Joseph B. Woodworth
EMI Section Manager

jbw